Diseases of Rubber in Ceylon

BY

R. K. S. MURRAY, A.R.C.Sc.

ISSUED BY THE

RUBBER RESEARCH SCHEME (Ceylon).

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PREFACE.

The greater part of this booklet was written in a private capacity as a chapter for Rutherford's Planters' Note Book. Thanks are due to the proprietors, The Times of Ceylon Company Ltd., for permission to reproduce the text in a Rubber Research Scheme publication.

This booklet forms a companion volume to:—

(1) "Guide to the Preparation of Plantation Rubber in Ceylon," by T. E. H. O'Brien, M.Sc., A.I.C.

(2) "The Budding of Rubber," by R. A. Taylor, B.Sc.

both issued by the Rubber Research Scheme.

R. K. S. MURRAY.

November, 1930.

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DISEASES OF RUBBER IN CEYLON.

INTRODUCTION.

The diseases and pests to which *Hevea brasiliensis* is prone may be conveniently classified as follows :—

I. ROOT AND COLLAR DISEASES.

II. STEM DISEASES.

III. LEAF DISEASES.

IV. DISEASES AND PESTS OF NURSERY PLANTS.

To these may be added

V. DISEASES AND PESTS OF COVER CROPS.

No attempt has been made to give an inclusive account of all the pathological affections of the Para rubber tree; only such as are considered to be of importance in Ceylon are described. The booklet is intended primarily as a planter's manual, and unfamiliar technical terms have, so far as is possible, been excluded.

I. ROOT AND COLLAR DISEASES.

(a) GENERAL CONSIDERATIONS.

When the roots of a plant are attacked by a parasitic organism the conducting tissues of the roots are killed. The feeding rootlets may or may not be affected in the first place according to the nature of the attack, but in any event the main lateral roots are unable to act as conducting channels along which the water may pass to the aerial portions of the plant. The latter are thus starved of water and the effect is seen in a wilting and fall of the leaves followed by a dying-back of the green shoots, and, in the case of *Hevea*, a cessation of latex flow. When a Rubber tree exhibits these symptoms its root system is already to a large extent defunct, and the whole tree soon dies.

These symptoms are similar in nature, though not entirely in degree, whatever organism has attacked the root system, and could indeed be artificially induced by cutting most of the lateral roots. It is thus apparent that an inspection of the aerial portion of the tree alone will not usually enable a correct diagnosis of the disease to be made. The roots must be exposed and the causative organism found.

Most root fungi spread by contact from root to root by means of a vegetative mycelium either on the surface of or within the tissues of the host. By the time a tree is found to be diseased it is usually too far gone to be cured by any form of treatment. Control measures have therefore for their object the prevention of the spread of the causative fungus from diseased to healthy trees, and the removal of all actual and possible sources of infection. Were all jungle stumps to be removed from Rubber clearings before the Rubber matured the danger from root disease would to a large extent be eliminated. This practice is, however, too costly for general application, and it behoves the planter to keep a careful watch for cases of root disease and, on discovery, to treat these promptly and carefully to prevent their spread. The correct method of controlling root disease is described under the heading *Fomes lignosus* since it is this disease which requires most stringent measures, but the methods outlined are generally applicable to other root diseases.

There are a number of fungi with which root diseases of Rubber are associated, but before describing these diseases under the headings of the fungi which are commonly supposed to cause them, reference must be made to a theory, which, if proved to be correct, would greatly alter our conception of the causation of root disease.

(*b*) CAUSATION OF ROOT DISEASES.

For some years Dr. Small, formerly Mycologist of the Department of Agriculture, Ceylon, has maintained that the fungi such as *Fomes* (*lignosus* and *lamaoensis*), *Ustulina*, *Poria*, etc., which are commonly associated with root disease, are not primary parasites and are not capable of attacking healthy unwounded roots. He further postulates that their entry into a root is preceded by an attack by another fungus, *Rhizoctonia bataticola*. This theory applies not only to *Hevea* but to other woody plants, and has aroused much controversy in Ceylon and elsewhere. In support of his view Dr. Small affirms that in nearly every case of root disease which he has examined *Rhizoctonia* has been found either alone or in association with other organisms under circumstances which suggest that the attack of *Rhizoctonia* was prior to that of the other fungi. In inoculation experiments he has failed to secure infection on healthy Rubber roots with *Fomes lignosus*, *Poria*, and *Sphaerostilbe*, while *Rhizoctonia* is

known to be a strong parasite on certain herbaceous plants. On the other hand many investigators are satisfied that these fungi can be parasitic on woody roots without being preceded by *Rhizoctonia*, and the great mass of field evidence indicates that *Fomes*, *Ustulina*, etc., are active parasites. The relative importance of these fungi is not yet known. It is probable that *Rhizoctonia* is parasitic on Rubber and can cause its death under certain conditions, but it is extremely doubtful if it necessarily precedes the other wood-destroying fungi.

As far as the planter is concerned the importance of the issue lies in the necessity for control measures. If *Rhizoctonia* is the only important root parasite, trenching and removal of roots are possibly unnecessary measures since *Rhizoctonia* does not spread through the soil by means of a mycelium from one root to another. The writer, however, considers that the necessity for stringent control measures exists in any event, since even if *Fomes*, etc., are not primary parasites they are at least strong secondary parasites and hasten the death of any tree they attack. If this opinion is justified the controversy regarding the causation of root diseases is more of academic interest than of practical importance, and need not greatly concern the Rubber planter. Until further experimental evidence is available it is wise, therefore, for the planter to regard *Fomes*, *Ustulina*, etc., as disease agents, and to enforce control measures accordingly.

In the present section *Rhizoctonia bataticola* is regarded as one of the fungi causing root disease of Rubber, and the other diseases are discussed under the usual headings.

(c) *FOMES LIGNOSUS.*

The root disease caused by *Fomes lignosus* is one of the commonest and certainly the most formidable to which Rubber in Ceylon is liable. The fungus has a wide variety of hosts and will readily attack any dead jungle stumps or roots which are left lying in a cleared area. It is from such dead wood that infection in a Rubber clearing usually originates. Rubber stumps left after thinning out or old Tea roots which have not been properly eradicated may also become centres of infection.

Symptoms.—The first step in the identification of any root disease is careful exposure of the lateral roots. When the tree is attacked by *Fomes lignosus* the fungus will usually be immediately evident as a mycelium consisting of white or yellowish or pinkish strands running over the surface of the roots, and adhering firmly to the bark. This mycelium is the vegetative part of the fungus. When young it consists of fine white threads which later coalesce into coarser discoloured strands. The cortex and wood of an attacked root are permeated by fine mycelial threads which feed on the cells, thus causing them to break down and the root to rot.

Many wood-rotting fungi of the class to which *Fomes* belongs have similar mycelial characteristics, and in some cases the fungi cannot for certain be identified without fructifications. The strands of *Fomes* may, however, be distinguished from those of harmless fungi by the manner in which they adhere closely to the bark of live roots; fungi which are not parasitic on *Hevea* roots can merely grow over the roots without penetrating the bark. In many cases the identification of a mycelium in the soil of a suspected area is not easy. Careful observation and experience, however, will usually enable a planter to tell whether the fungus is dangerous or harmless.

If the diseased tree has shown symptoms in the foliage the attack in the root system will probably have reached an advanced stage. Many of the laterals will be affected and the fungus may have reached the tap root. *Fomes* causes a soft and sometimes a moist rot of the wood. Diseased roots soon become disintegrated and lose all their mechanical strength so that affected trees may be blown over by a high wind before being discovered.

The fructifications of *Fomes* are not formed until the disease is in an advanced stage or the tree is dead, and a diseased tree should always have been found and removed before fructifications are formed. In any infected area a search should be made for fructifications on neighbouring stumps or dead wood. The fructification is produced as a bracket growing out horizontally from the diseased wood. When fresh, the upper surface is rich red-brown in colour with a lighter coloured margin, whilst the under side, which consists of a large number of very minute pores, is orange in colour. As the bracket becomes older and dried up the upper surface fades to a pale-orange colour, while the lower surface becomes dark-brown. On breaking the specimen in two the upper layer will show white and fibrous and the lower red-brown. This colouring serves to distinguish the fructification from that of a harmless fungus, *Polyporus zonalis*, which is similar in colouring but does not show the two layers in section.

Although these fructifications produce spores which may be blown about and cause fresh infection, the chief means by which the disease spreads is by vegetative growth of the mycelium by contact from one root or stump to another. Control methods must accordingly be such as to prevent the spread of the fungus from diseased to healthy trees. The fungus can to a limited extent travel independently through the soil, though it will always be found that the mycelium is somewhere attached to a piece of wood from which it draws its nourishment. Under moist conditions the spread of *Fomes* mycelium in the ground is very rapid, and this fact makes *Fomes* the most dangerous of all root diseases. If the control measures advocated below are carefully carried out the spread of a *Fomes* area can be absolutely prevented except where the rocky nature of the ground renders their execution impracticable.

Control.—The spread of *Fomes* can be prevented by isolating the area in which the fungus is present by a trench of adequate depth. Such a trench, however, is quite useless unless it is outside and completely enclosing the affected area. A great deal of time and money has been wasted in the past by digging excellent trenches in the wrong place. If they are dug too close in the fungus is left outside and the disease will break out again. If, on the other hand, a guard trench is flung wide out so as to include several healthy trees on all sides, these trees will ultimately become affected and will succumb to the disease. The large number of outbreaks of *Fomes* at the present time in the immediate vicinity of o'd areas is testimony to inadequate treatment in the past. In order, therefore, to dig the isolating trench in the correct position the extreme limits of the disease on all sides must be found. After the dead tree or trees have been removed the ground must be opened up, following out diseased roots in an ever-widening circle until the outside limit of the affected area is found. The trench may then be dug a few feet outside this line and completely enclosing the area with the certainty that no diseased material has been left outside it. The depth to which the trench must be dug depends to some extent on the nature of the soil since lateral roots lie deeper in some soils than in others; in general a minimum of 2 ft. is recommended. In digging the trench and working over the ground all soil, roots, etc., must be thrown inwards. As far as possible all roots must be removed from the ground and burnt *in situ*. Roots smaller in diameter than a lead pencil may be safely left since these will quickly rot away. If *Vigna* or any other cover crop is present this must be removed and burned together with the roots. No cover must be allowed to grow on an affected area, and isolation trenches must be kept clean.

This treatment is more expensive than the method of placing entire reliance on guard trenches. It is, however, the only certain method of preventing the spread of the disease and is fully worth the extra expense and trouble involved. (For treating a large *Fomes* area where several trees are involved a cost of Rs. 6 or Rs. 7 per tree removed is an average figure on hilly and rocky ground). In addition, it is often possible by this means to save a number of trees on the margin of the diseased area by cutting off and removing diseased portions of their lateral roots. If entire reliance were placed on trenches these trees would ultimately be killed. There is the additional advantage that an area cleared of all diseased material may safely be replanted in a comparatively short time, *i.e.*, about two years.

An application of lime to an affected area was formerly recommended, but this has now been shown to be useless. Applications of other chemicals such as copper sulphate and Bordeaux Mixture are also of doubtful value.

If all diseased roots are removed as advocated above there should be no necessity for any further treatment, and even a guard trench may be regarded as only an additional precaution.

The essential points in root disease treatment may be summarised as follows :—

Remove affected trees, including all roots, diseased or otherwise, and also *Vigna*, and burn *in situ*.

Follow up diseased roots, working outwards from the centre of infection, until the limit of the disease on all sides is found.

Dig an isolation trench at least 2 feet in depth outside and completely enclosing the affected area. Subsequently keep this trench clean.

(*d*) *USTULINA ZONATA.*

This fungus has a large range of hosts, and, in addition to being one of the most destructive parasites on Rubber, is the cause of a common root disease of Tea. *Ustulina* develops freely on felled *Hevea* logs and stumps, and its prevalence amongst old Rubber at the present time is largely due to the practice, which was common in the early days of thinning out, of leaving the logs to rot amongst the standing Rubber. In low-country districts *Ustulina* is the cause of more deaths in old Rubber than any other fungus. It is more liable to attack old than young Rubber.

Symptoms.—*Ustulina* may attack a Rubber tree in three different ways :—

(1) As a root disease.

(2) As a collar rot at the base of the trunk.

(3) As a wound parasite on the stem of the tree, developing in old canker patches, in branches broken by the wind or sawn off, or on trees scorched by fire. The disease may also develop in a fork irrespective of any previous wound.

Although this section deals with root diseases, it is convenient to consider all types of *Ustulina* attack together.

(1) *Ustulina* may gain entry to the root system of a Rubber tree *via* the tap root or a lateral root. Whatever the mode of attack the fungus has usually spread to both tap and lateral roots before the disease is discovered. Where the tap root is destroyed the tree is often blown over before any sign of disease is noticeable in the foliage. The disease commonly spreads up a main lateral root and attacks the collar on one side. (This form of attack is described under paragraph 2). If the disease is not noticed according to either of these symptoms the fungus slowly spreads along the laterals and round the tap root, and as the decay of the roots progresses the branches gradually die back.

Unlike *Fomes lignosus* the fungus produces no external mycelium, and it is to this fact that the comparative slowness of the progress of the disease in the individual tree is due. Diseased wood is dry and tindery with irregular but clearly-defined black lines running through it. These lines are really edges of thin sheets of black tissue. Although these black lines invariably occur in wood attacked by *Ustulina* they are not always an indication of this disease, since other fungi of the class to which *Ustulina* belongs also form such lines. The most reliable diagnostic feature of *Ustulina* attack on *Hevea* is the formation of white or slightly discoloured "fans" of mycelium between the bark and the wood.

The fructification of *Ustulina* is seldom formed on roots since these are not exposed to the air; it will be described in connection with collar rot.

(2) An attack at the base of the trunk is one of the commonest and most destructive manifestations of *Ustulina*. The disease may spread to the collar up a lateral root or may occur quite independent of any attack in the root system. In either case the disease is often not discovered until fructifications are produced. By this time the fungus will have penetrated the wood for a distance of some inches into the trunk, and if all the diseased tissue is excised a large hollow is formed. A tree attacked in this way will probably show no symptoms in the foliage, and will yield latex freely on the opposite side and above the affected area. The diseased wood shows the same characteristics as described for root attack.

The fructification is first seen as a small whitish flat cushion upon the surface of the stem, and when young has a soft velvety surface. The colour soon becomes greenish grey with a white margin; subsequently the fructification hardens and becomes darker in colour until when mature it is black and brittle in texture. Each fructification is about four or five centimetres in diameter, but several may arise side by side and fuse together into a continuous plate of considerable size. The fructifications are typically corrugated or concentrically zoned. When the fructification is young it produces spores (conidia) upon the surface of the cushion. These are easily detachable and, being blown about by the wind, provide a dangerous means of fresh infection. Later in the life-history of the fructification a second spore form is produced in minute cavities (perithecia) just below the surface. When these spores are ripe they are extruded through the mouths of the cavities, which are seen as black points on the surface of the mature plate.

A fructification very similar to that of *Ustulina* is produced by a closely allied fungus, *Kretzschmaria micropus*. The fructification is similar in colour and consistency but is divided up into a coral-like mass. For practical purposes the planter may consider *Kretzschmaria* to be a modified form of *Ustulina*.

(3) *Ustulina* may gain entrance to the woody stem of the tree through any wound or damaged part. Whether the disease originates in an old canker patch, on a broken or cut branch, or in a fork, the symptoms are similar to those where the root or collar is involved. Attack in the stem is due to spore infection, the wind-borne spores lodging in rotten bark scales or any other similiar unevenness. The mycelium penetrates the bark and the wood and causes the typical friable rot. The affected branch may be blown off, but as a rule the fructification will be formed before the disease is sufficiently far advanced, and the disease should be discovered. The decayed area is usually of considerable dimensions before the disease is found, and very large fructifications are sometimes seen. Latex frequently exudes from the tissue round the wood and is seen as black streaks running down the stem. In the later stages boring beetles may gain entrance to the wood.

Control.—In cases of root attack the method of treatment is as described for *Fomes lignosus*. Owing to the slower rate of spread of *Ustulina* it is not often found that many trees in a group are affected.

Since *Ustulina* is almost entirely a wound parasite its incidence can to a large extent be controlled by enforcing strict methods of estate sanitation. All dead stumps and logs must be burned, since if left lying in the field they are readily attacked by *Ustulina* and provide sources of fresh infection. All wounds caused by broken or cut branches must be tarred to prevent entry of the fungus. For a similar reason canker patches must not be neglected. A careful watch must be kept for fructifications of *Ustulina* at the collar of the tree or in the branches, and any case treated immediately.

In the case of collar attack all diseased tissue must be chiselled out and the resulting cavity filled with some type of permanent filling. Concrete with a cement facing has been found very successful provided that the filling is finished off level with the surface of the wood and not brought out flush with the bark. A description of this treatment is given in *Rubber Research Scheme Quarterly Circular, 1925, Part 4*. Such work is more successfully done if the disease is detected at an early stage. Periodical tree-to-tree inspection should therefore be made, and any bark which seems rotten should be carefully examined.

When *Ustulina* is discovered aloft it is usually necessary to cut off the affected branch, or, where a fork is attacked, to pollard the tree below the fork. If the main trunk of a large tree is attacked the disease may sometimes be treated by excision of all diseased wood and bark. In cases where the latter method is employed particular care must be taken to remove all diseased tissue or else the treatment is a waste of money. It is a sound measure to paint over any young fructifications with tar or disinfectant before commencing the treatment in order to prevent spores being blown about and causing fresh infection.

(*e*) *FOMES LAMAOENSIS.*

The disease caused by this fungus is commonly known as Brown Root disease, and originates from old cacao or jungle stumps. The disease is found on a wide range of hosts, including Rubber, Tea, cacao, and kapok, and has been reported from most countries in the Eastern tropics.

It is one of the commonest root diseases of *Hevea* in Ceylon, but on account of its slow rate of spread does not cause so much damage as *Fomes lignosus*. Whereas the latter fungus can spread independently through the soil from a jungle stump, and may attack a number of trees in one spot before any one of them shows signs of disease, *F. lamaoensis* spreads extremely slowly, and probably only along the roots of the trees. It does not, therefore, infect the neighbouring trees unless their roots are in contact with those of the diseased trees, and its progress is so slow that as a rule the first affected tree is dead before the neighbouring trees are attacked. In general, therefore, only one tree is killed at each centre of infection, unless the dead tree is left standing for some years.

Symptoms.—The aerial symptoms exhibited by trees attacked by Brown Root disease do not differ from those of other root diseases. The leaves wilt and fall off and the tree dies. But, if the roots are exposed, the special characteristics of Brown Root disease are immediately evident, and there can be no mistake in the diagnosis. The roots, especially the tap root, are incrusted with a mass of sand, earth and small stones to a thickness of three or four millimetres, and this crust may extend up the stem for several inches. This mass is cemented to the root by the mycelium of the fungus, which consists of tawny brown threads collected here and there into small sheets or nodules. In the early stages the predominating colour is brown and the name given to the disease then appears appropriate, but as it grows older the fungus forms a black, brittle, continuous covering over the brown masses of hyphae. In all stages, however, the disease is distinguished by the encrusting mass of stones and earth which cannot readily be washed from the root.

If the outer coat is scraped away the cortex of the root is found to be decayed, and usually coloured brown or brown mottled with small white patches. The diseased root is soft and permeated by fine brown lines, which are really edges of plates of brown tissue. When the decay is advanced this brown tissue forms "honeycomb" structures in the wood. The decayed wood is usually dry, but when the tree is growing under moist conditions the cells of the "honeycomb" are often filled with water. The disease sometimes take the form of a collar rot *via* a lateral root, similar to that caused by *Ustulina*. The fungus has also been found attacking *Hevea* stems.

The fructification of *F. lamaoensis* is very rarely found and is of little importance to the planter. It is liable to be formed in rare cases of stem attack or on *Hevea* logs.

Control.—The same treatment as described for *Fomes lignosus* should be carried out. Owing to the slow rate of spread of the fungus it is seldom that the disease has to be followed outwards to any great distance.

(f) SPHAEROSTILBE REPENS.

The parasitism of this fungus on *Hevea* roots is open to question as the result of recent inoculation experiments carried out at Peradeniya. Since, however, the fungus undoubtedly attacks Rubber under certain conditions, be they such as to justify the description of *Sphaerostilbe* as a primary parasite or no, the disease will be considered as of the same standing as those caused by *Fomes* and *Ustulina*.

The disease occurs most frequently in swampy or sour soil though it has been found in normally drained ground. The fungus also attacks arrow-root, papaw, and *Canna*, and is found on jak and dadap logs from which it is liable to spread *Hevea*.

Symptoms.—The mycelium of the fungus at once characterises the disease. When the root is dug up the cortex is found to be decayed, but there is no external mycelium. If the cortex is removed black or red flattened strands are found running over the surface of the wood. These are usually about 2 millimetres in breadth, and, if the fungus is living, stand out prominently from the wood. When young these strands, or "rhizomorphs," are red externally and white inside, but later they become black and form little more than a film on the surface of the root. The outer surface of the rhizomorphs is sometimes clearly marked with a herring-bone pattern. The inside of the cortex and the outer layers of the wood are usually deep blue or purple in colour, and have a particularly foul smell. This smell, although probably caused not by *Sphaerostilbe* but by secondary organisms, is nearly always present though not entirely distinctive for the disease.

The fructifications of the fungus are produced on diseased tissue or on exposed rhizomorphs, and are of two kinds. The conidial form consists of short, erect, red, hairy stalks surmounted by a white or pinkish globose head. These are produced first and occur in large numbers. The perithecial stage is formed on the same area, but is often not produced at all. The spores are enclosed in sacks (asci) within a small case (perithecium). The perithecia are very small dark red bodies and are produced crowded together on the mycelium or on the old conidial stalks.

Control.—As for other root diseases. Since the fungus exhibits a predilection for swampy soils, adequate drainage will be a helpful measure.

(*g*) *PORIA HYPOBRUNNEA.*

Red Root disease caused by this fungus is, in Ceylon, one of the most uncommon to which *Hevea* is prone. It originates from old jungle stumps and more particularly from *Hevea* logs.

Symptoms.—The appearance of diseased roots varies somewhat according to the age of the tree attacked. On young trees the mycelium forms stout red strands on the exterior of the tap root. If cut these strands are seen to be white internally. When old the strands turn black. The root is often found to be incrusted with stones and earth as in Brown Root disease, though never to so great an extent. The diseased wood is soft and friable and permeated with red sheets.

In older trees the diagnosis is often more difficult. The mycelium may all have turned black, though red strands are sometimes found on a recently attacked lateral root. The diseased wood is generally soft and wet and exposed wood surface are red-brown in colour.

The fructification is uncommon but is sometimes found at the collar of a diseased tree. It forms a flat plate closely applied to the surface of the root or stem. When young it is yellowish-white but subsequently turns reddish-brown. The upper part consists of a layer of small tubes which are seen in a surface view as small holes.

Control.—The treatment is the same as for *Fomes lignosus*.

(*h*) *XYLARIA THWAITESII.*

Xylaria Thwaitesii, as a cause of root disease of *Hevea* in Ceylon is of extremely rare occurrence. It is considered worthy of mention, however, owing to its comparative severity in the few cases recorded. The disease has only been reported from the Kegalle district in Ceylon; it also occurs in Java and Indo-China.

Symptoms.—The external mycelium of the fungus is represented by flat irregular bands of variable width on the surface of affected roots. These are white when young and are thus seen on the growing margin of the mycelium. They soon, however, become black and form an extensive network over the root, the bands coalescing in places to form irregular black patches. In this condition the external appearance is somewhat similar to an advanced case of Brown Root disease.

The inner cortex is yellowish-brown in colour, and friable. Where the tap root or a large lateral is attacked latex is often found to have exuded from the cortex in numerous places and formed large lumps of black scrap.

In advanced cases the appearance of the wood of diseased roots is quite characteristic. On splitting the roots longitudinally the central region is sometimes found to be greyish-brown in colour, the wood being hard yet moist. This region may be delimited by a black line from the outer wood which is yellowish-brown in colour and somewhat more decayed. It is noteworthy that the wood remains quite hard until the final stages of decay. The extreme wetness of thoroughly diseased roots is a striking feature; on breaking a root, water will often spurt into the face. This combination of hardness and wetness is quite distinct from the effect produced by any of the other root fungi. The fungus appears to spread very slowly, and in this respect is comparable with *Fomes lamaoensis*, the cause of Brown Root disease.

The fungus will apparently not attack exposed portions of roots. Where an affected root comes to the surface the portion lying on and under the ground is diseased while the upper part exposed to the air is quite healthy. The margin of the diseased tissues is sharply delimited and becomes marked by a line of callus growth from the healthy portion. It is along this line, *i.e.*, where a diseased root comes to the surface, that the fructifications are mostly found.

The fructification consists of a cluster of club-shaped growths arising from a basal mass. Three or four stout stalks arise which may divide into numerous finger-like protuberances. When found in the field the "clubs" are usually a dirty white at the extremity, darkening in colour down to the base. Subsequently they turn black. The fructification is usually one to three inches in height, and the basal mass about two inches in diameter. When mature the upper part of the club-shaped stroma bears perithecia containing spores.

Control.—As for other root diseases.

(*i*) ROOT DISEASE OF STUMPS (*BOTRYODIPLODIA THEOBROMAE*).

Botryodiplodia Theobromae is well known as the cause of a die-back of *Hevea* stems, but it is also a common cause of the death of stumps planted out in the field from nurseries. The fungus is regarded as a wound parasite, and in the majority of cases gains entrance to the stump through wounds inflicted in planting. It is possible, however, that there are virulent strains of the fungus which are capable of attacking uninjured plants.

Symptoms.—When the root is split open the wood is found to be discoloured a blackish-grey, or with black streaks. The cortex is also discoloured internally and bears the characteristic "sooty" masses of spores.

Control.—Affected stumps must be removed and burned, and the holes should be limed before supplying.

(j) *RHIZOCTONIA BATATICOLA* (*MACROPHOMINA PHASEOLI.*)

It has already been mentioned that the importance of this fungus as a cause of root disease of *Hevea* is not yet clearly known. *Rhizoctonia* is probably capable of attacking healthy roots under certain conditions, and since future experiments may prove it to be of greater importance than it is now commonly regarded, it is as well that the planter should be acquainted with the symptoms of disease and appearance of the fungus in Rubber roots. The fungus has been identified with a pycnidial form of fructification known as *Macrophomina phaseoli*, and should correctly be called by this name. To avoid confusion, however, the former name of *Rhizoctonia bataticola* will be used.

Symptoms.—*Rhizoctonia* enters the root system *via* the small feeding roots and thence travels slowly upwards into the larger roots. It is in the fine laterals that the fungus is most commonly found. It produces no conspicuous vegetative mycelium either externally or in the tissues of the root, and will therefore often escape the eye of even the trained observer. In an affected root the inner layers of the cortex are attacked, and the latter therefore usually lies as a loose sheath over the wood. If the cortex is removed the wood is found to be hard, dry, and brittle, and is studded throughout with very minute black spots. These are sclerotia, or resting bodies of the fungus, and are also found on the inside of the cortex. Fine black or dark-brown lines are also sometimes seen in the wood. The symptoms are the same in large roots though larger sclerotia may be found. Attacked roots are undoubtedly killed and rendered functionless, but it has been argued that it is only after the tree has been weakened by other fungal attack or by some physiological cause that *Rhizoctonia* is able to gain entrance.

Control.—In the present state of our knowledge no control measures can be suggested, beyond increasing the vitality of the trees by cultivation methods.

(*k*) TERMITES.

Termites, or "white ants" as they are commonly called, include a number of genera and species, some of which can attack woody plants, while others are merely scavengers of dead vegetation. In Malaya and the Dutch East Indies *Coptotermes gestroi* has for some years been notorious as a parasite on *Hevea* roots. This species is not known in Ceylon, and until recently it was thought that none of the Ceylon termites were able to attack healthy Rubber trees. Unfortunately this view can no

longer be entertained, and in the light of recent observations it seems probable that termites may come to be regarded with concern by the Rubber planter in Ceylon.

Termites may, for all practical purposes, be grouped into two classes :—

(1) Those that nest in timber or tree stems, of which *Calotermes* is the type genus;

(2) Those that nest in the soil. *Coptotermes* is the important genus in this class.

(1) **Calotermes.**—Several species of *Calotermes* have been found invading the branch system of Rubber trees, and there seems no doubt that these insects, having gained entrance through dead or diseased wood such as is provided by *Ustulina* attack or a broken branch, can penetrate into and destroy healthy wood. In the absence of such essential points of entry it is considered that no species of *Calotermes*, in the winged adult state, could become established in *Hevea* trees. The prevention of attack is consequently dependent upon attention being directed to these points, *Ustulina* patches being treated, and all broken or cut surfaces cleaned up and tarred.

As is well known a colony of termites consists of several forms of the same insect, but in the class which nest above the ground in trees there is no worker caste. All individuals, with the exception of soldiers, are destined to develop into reproductive adults either with or without wings. It is the winged adults which are responsible for a fresh invasion by alighting on an area of dead or diseased wood. The galleries in the wood made by termites are familiar to all planters.

(2) **Coptotermes.**—As mentioned above the genus *Coptotermes* builds its nest in the soil. The termites usually enter their host plants underground through the roots, and there is one species, *C. ceylonicus,* which has been found to attack Rubber roots in Ceylon in this way. Although in most of the cases so far reported the termites have been associated with either *Ustulina* or Brown Root disease, it seems probable that *C. ceylonicus* is a primary parasite on *Hevea* and can attack healthy roots. Extensive excavation of the tap root and trunk of the tree has usually taken place before the infestation is discovered. *Coptotermes* can also gain entrance to a tree through decayed wood above ground, but communication must be maintained with the soil by covered runways.

Entry through the roots cannot be prevented, but the proper treatment of broken and cut branches will minimise the risk of infestation by the second method.

For further reference to termites in *Hevea* and the means by which the genera may be identified the reader is referred to *Rubber Research Scheme Quarterly Circular 1930, Part 3.*

(l) *BATOCERA RUBUS.*

In addition to the diseases caused by the fungi described above the root system of a Rubber tree may be attacked by the larva of a longicorn beetle, *Batocera rubus*. It has not been definitely established that this animal can penetrate living cortex and attack a healthy root, and it is usually found in roots which have previously been attacked by *Ustulina* or Brown Root disease. The writer has, however, seen one case in which there was no evidence of previous fungal attack. The pest is not of much importance and as a rule trees are only attacked singly.

Symptoms.—The injury may take two forms—either central or peripheral. In the former case the centre of the tap root is hollowed out, and the tunnel may extend well up into the base of the stem, increasing in diameter as the grub grows larger. In the second case the attack is from the outside, usually at or just below ground level. Occasionally the point of entry may occur higher up on the stem. Irregular cavities are eaten through the bark into the wood of the tree. An affected tree behaves as though attacked by root disease. The crown may become thin and ultimately die, but where the tap root is attacked the tree usually blows over.

The larva is a fat grub, up to three inches in length, creamy white in colour with a small, triangular, dark-brown head. The body is segmented, somewhat flattened above and below, and tapers from head to tail.

Control.—An affected tree should be removed and all roots burned, and the grubs searched for and destroyed.

(m) COVER CROPS AND ROOT DISEASE.

Before concluding the section on root diseases brief reference must be made to the relation of cover crops to the occurrence and spread of root disease. Now that the establishment of a ground cover has been almost universally adopted the matter is one of considerable importance.

Erect woody covers such as *Tephrosia candida* (Boga medeloa), *Crotalaria spp.*, etc., may assist the spread of root disease in Rubber by being liable to attack by the same root fungi. *Fomes lignosus* and *Fomes limaoensis* are known to attack *Crotalaria spp.*, and *Tephrosia candida*, while the latter cover may also be attacked by *Poria hypobrunnea*. It is probable that associations of the Rubber root fungi with other species of green manure crops will be noticed as the use of these crops is extended, but it is unlikely that serious danger will result. Green manure crops should not, however, be grown in areas known to be affected with root disease.

Whereas in the case of erect covers the spread of root disease may be favoured by the cover plants themselves being liable to the disease, in the case of creeping covers such as *Dolichos Hosei* (*Vigna*), *Centrosema pubescens*, *Calopogonium mucunoides*, etc., the effect is more indirect though of far greater consequence. The most important means by which the growth of a ground cover influences the spread of root disease is in causing moist conditions in the surface layers of the soil, since such conditions favour the growth and spread of the mycelia of the fungi which cause disease. Under a cover of *Vigna* the mycelium of *Fomes lignosus* will readily grow over stones and rocks which, had they been exposed to the sun and air, would have offered no medium for the spread of the fungus. The mycelial strands of *Fomes* can often be observed growing along the older runners of the *Vigna*, and it is possible that the fungus derives nourishment from dead *Vigna* mulch. In addition, a ground cover may aid in the spread of root disease by concealing it, so that its detection is rendered more difficult. This difficulty is largely overcome by keeping a circular area 6-8 ft. in diameter round every tree clear of *Vigna*. The detection of root disease, and more particularly of *Ustulina* collar rot, is thereby made easier.

The effect of a thick ground cover on the spread of root disease has recently been made very evident on estates on which a good cover has been established for some years. When a case of root disease is discovered it is usually found that the disease has spread much further than would otherwise have been the case. This applies in particular to *Fomes lignosus*. It should be understood that the assistance in the spread of root disease fungi by cover crops is not in itself an argument against growing them, and it would be a mistake for an estate to deny itself the undoubted benefits to be derived from these crops because of the possible danger from root disease. It is important, however, not to grow cover crops on areas known to be affected with root disease, and in the treatment of a root disease area to clear away and burn any cover that may exist.

II. STEM DISEASES.

(a) BROWN BAST.

The disease of the tapping panel known as Brown Bast, of which the cause is not yet known, is of universal occurrence in all mature areas of Rubber in Ceylon. Since the immediate result of the disease is to check the flow of latex from the affected tree, its importance, if a large percentage of trees is affected, will be readily appreciated. On most estates in the chief Rubber-growing districts the proportion of trees affected with Brown Bast is probably not higher than 5%, but in drier districts such as Uva, Matale, and Kurunegala the proportion may rise to 30%. In these districts the disease must be considered as the most serious factor adversely affecting yields.

In former days estates were able to remove trees affected with Brown Bast in the ordinary course of thinning operations. The limit to thinning out has now, however, been reached, and planters are faced with the problem of treating this disease or inevitably losing valuable trees and thereby a percentage of their full potential crop. It is important, therefore, for all planters to be fully acquainted with the symptoms and method of treatment of Brown Bast.

The following account is largely abstracted from *Rubber Research Scheme Bulletin No. 48*: "Brown Bast of Rubber and its Treatment" by J. Mitchell, A.R.C.Sc.

Symptoms.—The onset of Brown Bast development is usually indicated by the failure of the tapper to produce the normal amount of latex from the tapping cut. An examination will show that portions of the cut remain dry except where the cut is made very close to the cambium. At this stage it frequently happens that the latex bubbles on the cut and fails to run in the usual way so that one or two pads of coagulated scrap are formed with intervals between which are quite dry. It is important that the disease should be located at this stage, and this can only be done if a system of regular inspection is carried out.

The tapper may continue to tap the tree, but the only result will be a steadily diminishing flow of latex until the whole cut goes dry. A close examination of the cut will then show that the tissues are yellowish-green and speckled with dark-brown spots. Instead of the bark having a gritty texture it is smooth and cheese-like and often watery. A cut made when the sun is shining on to it will show quite clearly the watery condition of the bark.

Later on longitudinal cracks may appear in the bark, and sections of varying size can be prized off. When once seen this condition is not likely to be confused with the simple scaling of bark which is common on a large number of trees. If a scraping is made at this time the Brown Bast discolourations, of which the spotted "pepper-and-salt" type of appearance is most characteristic, are more noticeable than at any other time and leave no shadow of doubt as to the cause of the drying up of the tapping panel. The tree may remain in this condition for the rest if its existence, steadily throwing off sections of bark, but still remaining dry and diseased. In other cases, computed to be about 30% of affected trees, nodular growths appear, and this is the stage with which everyone is familiar. These nodules show an infinite variety of shape and size, and if left untreated they eventually unite with the wood of the tree, and removal without injury is an

impossibility. Unless treatment is carried out at an early stage the great majority of trees which reach the nodular stage are completely ruined and have to be removed.

It will be seen from the above sequence of events that it is of the utmost importance that the disease should be located in the early stages, and after a little training an intelligent cooly becomes very quick to detect cases. Where there is any doubt such trees should be marked for re-examination at a later date. The necessity for such re-examination arises out of the fact that trees sometimes suffer from time to time with "temporary" dryness, and it is difficult to make a correct diagnosis. If due to Brown Bast the typical symptoms will appear in due course, but if not the trees will after a time renew their normal flow.

The cause of Brown Bast is somewhat obscure and many theories have been advanced to account for it. Most scientists consider that it is of physiological origin *i.e.*, that it is due to some physiological upset brought about by tapping. What the nature of this upset may be is not known, but it has variously been held to be a wound stimulus, exhaustion due to extraction of latex, disarrangement of pressures in the cortical cells, etc. On the other hand Keuchenius claims that Brown Bast is a pathological condition caused by a hitherto undiscovered organism. Other workers have also advanced the hypothesis that the disease is due to a non-filterable virus. The success of the isolation treatment appears at first sight to lend support to Keuchenius' theory, but it can probably also be explained on physiological grounds. The incidence of Brown Bast is accentuated by too frequent tapping, particularly if very thin shavings are removed.

Control.—In spite of statements to the effect that some affected trees recover without treatment, such cases must be extremely rare for the mass of evidence is entirely against such self-recovery. Similarly, the simple resting of trees which show the early symptoms has proved a failure as the disease has been found to extend its area during such resting period. It has, therefore, become necessary to adopt some method of treatment in order that affected trees may again be brought into tapping and become of value to the estates. (It is sometimes possible to tap nodular trees after the nodules have coalesced, since the surrounding bark is not usually diseased.)

Three methods of treatment have up to the present time been practised: stripping, scraping, and isolation. Stripping involves the complete removal of the bark to the cambium, but for success it is necessary that the bark should be well developed and not too hard. In Ceylon the bark is almost

always too hard for stripping to be easily and effectively carried into operation, and this method will not be described. Attention will be directed to a combination of the scraping and isolation methods which has been found most suitable for Ceylon conditions.

The tools required for the scraping operation are a 9-inch drawknife or spokeshave, a large scraper, and a small canker scraper. A set of tools recommended by the Rubber Research Scheme can be obtained from Messrs. Hunter & Co., Colombo. To ensure success great patience and care must be exercised by the operator, and in this matter coolies have shown remarkable facility, and there is no reason to anticipate that the requisite number of coolies cannot be trained to do the work successfully. The outer bark is removed with the drawknife, and then the diseased tissues are carefully removed with the large and small scrapers. The scraping must be continued until the latex appears in small pin points, and when this stage is reached the scraping should cease even though there are still small lines and points of discoloured tissue to be seen. To endeavour to remove every trace of discoloured tissue usually results in the production of wounds. In practice it has been found that the last traces of such tissue are removed in the scaling which takes place when the bark renews. The scaling is further encouraged by the application to the scraped surface of a 5% solution in water of Brunolium Plantarium or other standard tar-acid disinfectant.

The scraping method enables the operator to locate the limits of the disease, and on completion of the work it is now considered advisable to make an "isolation" cut all round the treated area. This is done with a sharp firm-bladed knife, such as a non-clasp hunter's knife. The cut should be cleanly made and penetrate to the wood, and the position of this cut should be marked with a smear of Cargilineum Mixture.

It is inadvisable to scrape for Brown Bast in wet weather since the scraped surface is very liable to become diseased. Newly-scraped surfaces should be protected with sacking, and this will also protect the delicate cortex from exposure to a hot sun.

This scraping and isolation treatment has been found very successful on Ceylon estates. The bark renewal is remarkably even and tapping can often be resumed after two years.

The isolation method introduced by Keuchenius has proved very successful in Sumatra. The actual operation is simple, but success is dependent on the ability of the operator accurately to determine the limits of the disease, and the best results are obtainable only when a highly trained staff is kept constantly employed in locating the disease. By test scrapings the

outside limits to which the disease has spread are defined. Then a deep groove is made with a tapping knife just outside the area known to be diseased, and this is followed by a cut to the wood with a sharp knife.

The isolation method is most successfully applied to small newly discovered affected areas. When estates in Ceylon have treated their old cases by the scraping method, and have established a routine system of Brown Bast treatment, it will no doubt be possible to apply the simple isolation method to new cases which are located by expert operators. In the meantime the "scraping plus isolation" treatment appears to give the best results.

The appearance of nodules is the final stage of Brown Bast development, though only a certain percentage of cases develop them. If the nodules are detected at an early stage they can be removed quite easily and without injury. Even when they have joined up with the wood of the tree they can often be levered out with a strong rigid knife. Many apparently ruined trees can thereby be greatly improved.

PHYTOPHTHORA PALMIVORA, formerly known as *Phytophthora Faberi*, is the cause of four diseases of *Hevea* in Ceylon, viz :—

Pod Disease, Secondary Leaf-Fall, Bark Rot, and Canker.

Pod Disease and Secondary Leaf-Fall will be considered under Section III.

(*b*) BARK ROT.

This disease of the tapping panel is known under various names —Bark Rot, Black Thread, Black Stripe, Stripe Canker etc. It attacks the recently tapped cortex in wet weather and may cause considerable damage; if it is allowed to develop unchecked the renewing bark may be entirely spoilt for future tapping. Bark Rot, however, is fairly easily prevented except under continuously wet conditions, and, once it has occurred, is amenable to treatment which will prevent the worst ravages of the disease.

The causative agent of Bark Rot has not, despite several attempts, been definitely established in Ceylon as the fungus *Phytophthora palmivora*, but since the symptoms appear to be identical with the disease in other countries in which *Phytophthora* is the proved cause, this fungus may be accepted as the organism responsible for the disease in Ceylon. It is possible that Bark Rot should be regarded as a group of diseases with several associated organisms rather than a single disease with one causative fungus.

Symptoms.—The disease is first evident as a number of vertical, depressed lines about half an inch long on the recently tapped cortex just above the tapping cut. These lines soon become black and spread upwards into the renewing bark and downwards into the untapped portion. On cutting into these areas it will be seen that the black lines extend through the cortex into the wood. The number of lines on the tapped surface depends on the intensity of the attack, but they are always found to be parallel to one another. If the disease is allowed to develop and the weather conditions remain wet, the lines spread out laterally forming narrow vertical wounds. Where the lines are close together these wounds coalesce so that sometimes a continuous gaping wound results. Sometimes latex exudes and coagulates in pads between the cortex and the wood. The healing of such large wounds is a process taking many years to complete, and in the meantime the bark is untappable. Even if the decay of the cortex does not spread laterally to any extent, the narrow vertical wounds, when healed over, will give the renewing bark an irregular surface difficult to tap.

Control.—Particular attention must be paid to the prevention of the disease rather than to its cure once it has occurred. Apart from the application of disinfectants to the tapping cut there are two considerations in estate practice which have a bearing on the occurrence of Bark Rot.

Newly-opened cuts are especially liable to be attacked by Bark Rot, and it is therefore important that they should be opened in settled dry weather. If new cuts are opened in wet monsoon weather bark rot is likely to result, since it is very difficult adequately to protect the tapped cortex with disinfectants during continuously wet weather. March is a satisfactory month in which to open new cuts after the resting period, and if a six-monthly change over is the practice the new cuts should be opened early in September, well before the break of the N. E. Monsoon.

The angle of slope of the cut is possibly a point of importance. If the cut is too flat the rainwater will run off slowly and the cut will remain moist—a condition favourable to the disease.

Whatever other precautions are taken Bark Rot cannot be prevented without having recourse to the use of disinfectant painting. In the past many disinfectants and mixtures have been used, and at the present time there are no doubt many alternative substances which prove effective. It is not proposed to discuss all these alternatives, but simply to give a recommendation which, it is believed, will secure as effective a measure of prevention as is possible in estate practice.

About three weeks after the new cut is opened make an application of Cargilineum Mixture "A" (5%) or "B" (10%). As late as possible before the burst of the monsoon, whether it be the S.W. or N.E. Monsoon, make a second specially careful application of Cargilineum Mixture. (Candarsan has similar properties, but Cargilineum Mixture is to be preferred as having been more fully tested). Thereafter apply Cargilineum Mixture as far as possible every 10 days or a fortnight when a dry spell gives the opportunity. It is essential that Cargilineum Mixture, being waterproof, be applied to an absolutely dry tapping surface. A thin smear is all that is necessary.

Since Cargilineum Mixture consists of an insoluble disinfectant in a waterproof base, it forms a greasy surface over the bark through which moisture cannot penetrate. The disinfectant is not washed out by rain, and the application is therefore of a more or less permanent nature and satisfactorily protects the cortex on which it is applied. The disinfectant, however, offers little or no protection to the more recently tapped bark beneath, and during the 10 days between successive applications there is ample opportunity for Bark Rot to develop in the unprotected cortex. Also, during the monsoon the tapping cut is often too wet for several weeks in succession for an application of a waterproof disinfectant to be made. In wet weather, therefore, the application of Cargilineum Mixture must be supplemented by the periodical application of a "water soluble" fungicide. For this purpose a 5% solution of Brunolinum Plantarium in water is satisfactory. This should be applied after every tapping during the wet weather, or at least after every second tapping. In order to render the painting visible a small proportion (4 oz. per gallon is suggested) of red oxide powder may be added to the diluted disinfectant.

Various "water soluble" disinfectants, which are equally as good as Brunolium Plantarium, are on the market. Care must be taken to find out the dilution at which these must be applied since they differ somewhat in strength. If too strong a concentration is used the delicate cortex is penetrated and killed for a certain distance, and wounding may result. The use of "water solubles" is troublesome but is an essential measure in preventing Bark Rot during very wet weather. All disinfectants are probably best applied on the day after tapping on collecting the scrap.

When once it has occurred Bark Rot can only be effectively checked if treated in the early stages. In such cases a 10% or 15% solution of Brunolinum Plantarium should be applied. The recommendations given above are applicable to districts in which Bark Rot is prevalent. On estates on which the disease does not commonly occur the preventive painting may be largely modified, and the troublesome use of "water-solubles" omitted.

In conclusion, certain warnings regarding the application of Bark Rot disinfectants may be given. Tar is definitely injurious to the young cortex unless diluted to a low concentration with some such substance as tallow, or liquid fuel. Some substances, e.g., liquid fuel, have a softening effect on rubber, and unless the application is made after removing the scrap, tackiness may result. When mixing a colouring matter with a soluble disinfectant too great a quantity should not be added, or there is a liability of it being washed down into the latex and discolouring the crepe if this is the final product.

(c) CANKER

The *Phytophthora* causing *Hevea* Canker is identical with that causing a similar canker of cacao, and is supposedly the same as the fungus causing Bark Rot. Moisture is essential for the development of the fungus so that Canker, like all diseases caused by "downy mildews," is a wet weather disease. The amount of damage caused by Canker in the branches is a debatable point, but when the disease attacks the tapping panel there can be no question as to its serious nature. Untreated Canker patches are also liable to afford entry for the spores of *Ustulina*.

Symptoms.—The appearance of Canker in its late stages is well known to all, but in the early stages there is, as a rule, very little outward indication of the disease; in young trees the affected parts may show darker brown, but in older trees this discolouration is not usually evident. Active Canker patches during wet weather are sometimes seen to be "bleeding" *i.e.*, exuding a flow of latex, or a reddish or purplish liquid. In many cases, however, the Canker develops in the bark over a large area without any open wound or outward indication of the disease; in this instance the first indication of Canker is a cessation of the flow of latex. In this case the bark should be lightly scraped here and there in order to examine the cortex. When healthy this is white, yellowish, clear red or mottled red and white in colour. Under the outer brown bark is a layer of green in untapped cortex, which in renewing bark is replaced by a red layer. When Canker has attacked the bark this green layer will turn black, while the cortex below is also discoloured and presents a sodden grey appearance with the diseased patch clearly outlined in black. In later stages this will turn a dirty red or claret colour, still with the well-defined black border. When cankered bark is cut or picked out with a penknife no flow of latex appears. On the advent of dry weather the fungus becomes inactive, and the diseased area presents a characteristic "scaly" appearance.

The disease is spread during wet weather by spores carried on the wind or washed down the stem; they will only germinate in water or on a damp stem. After germination the mycelium penetrates the cortex, destroying it from without inwardly. Canker may be looked for on the bark of the stem or branches on the tapping cut, or round the collar of the tree. Infection may lie dormant in diseased tissue for a considerable period, and it is probable that most stem canker is propagated from year to year in this manner.

The most serious type of Canker attack is when the tapping panel or collar is affected. Unless the disease is treated promptly the tapping surface may be seriously damaged, and the disease may extend right round the tree and "ring" it.

Treatment.—The recognised treatment for Canker is excision of all the discoloured cortex. This can be done quite easily since the appearance of the diseased bark is so well marked. The work is most satisfactorily carried out in dry weather since the bark then scales off readily and very little actual scraping is necessary. Active cases on the tapping panel or collar should, however, be treated when found whatever the weather conditions may be otherwise the disease may spread rapidly and kill a large area of bark. Exposed wood surfaces must be tarred, but tar must on no account be put on to the scraped cortex. Burning is likely to result, and if all diseased tissue has not been removed the disease will continue to spread unobserved under the tar.

On most mature Rubber estates a round of Canker scraping during the annual resting period will suffice to control the disease. If an application of a 10% solution of Brunolinum Plantarium in water is made to the Canker patches a few weeks before scraping, the scaling off of the diseased bark will be greatly assisted. Such a disinfectant should always be applied after scraping when this is done in wet weather.

(*d*) DIE-BACK (*BOTRYODIPLODIA THEOBROMEA*).

A dying-back of *Hevea* branches may result from a number of causes. There are two fungi, *Phyllosticta ramicola* and *Gloeosporium alborubrum*, which attack green shoots and may cause a die-back. The death of small twigs is nearly always the sign of poor conditions of growth, which may be the result of disease or simply lack of moisture or nutriment. Thus a general loss of foliage and death of the terminals is a characteristic symptom of root disease, and is also often consequent upon *Phytophthora* and *Oidium* leaf diseases. Severe Canker may also result in a die-back. "Stagheads" and dead branches are always seen when Rubber is grown under poor conditions such as are provided by badly drained or washed soils.

There is, however, a true "die-back" caused by *Botryodiplodia Theobromae* (usually referred to as *Diplodia*). This fungus has not been known to attack a healthy unwounded stem, but gains entrance through a wound or dead tissue. Any dead twigs caused by the above-mentioned factors offer sources of entry for *Diplodia*, and when once this fungus has gained entry it kills the tree back in a very quick and characteristic manner.

Symptoms.—*Diplodia* works downwards from the terminal shoot, killing the branches successively as it reaches their junction with the main stem. If left untreated the fungus will continue to work rapidly downwards until the whole tree is killed.

The fungus may also gain entrance to the cortex of the main trunk or a branch through any wound such as the stub of a broken branch or rotten bark in a fork. The disease works upwards and downwards, and the first indication may be cessation of latex flow on the side attacked, by which time it will probably be too late to save the tree.

The disease produces typical discolourations in the bark and wood. The bark becomes brownish in colour, and the cambium disintegrates to a slimy dark-brown layer. The fungus penetrates into the wood and discolours it a blackish-grey. Since the fungus when young is colourless and only turns dark on ageing, the disease has always spread further than is indicated by the extent of the discolouration, and this point must be borne in mind when cutting off diseased branches. The black spores of the fungus are extruded in "sooty" masses through crevices in the diseased bark.

Diplodia may also attack wounded exposed roots, sun-cracking being a common pre-disposing cause.

Control.—Since *Diplodia* is a wound parasite and very readily attacks any dead *Hevea* wood, the most important means of prevention is the maintenance of strict estate sanitation methods. All sawn ends of branches must be tarred, and broken branches sawn off clean, and dead wood must not be left lying about. It would be a counsel of perfection to advocate the removal of all dead branches and "stag-heads," but this is not a practicable measure. Large dead branches should, however, always be cut off and burned. Lightning is often responsible for killing branches and *Diplodia* is frequently found to gain entry by this means. Where a group of trees is found with many scorched branches, these should, therefore, be removed.

When a case of die-back is found all diseased branches must be cut off and burned, special care being taken to cut them off in healthy tissue well below the apparent margin of the disease. It is often found necessary to pollard a tree severely, but this is preferable to leaving diseased tissue behind

from which the fungus will spread. In the case of an attack on one side of the main stem it is sometimes possible to cut out all the diseased bark and wood, and tar the wound. It is seldom, however, that the disease is detected in a sufficiently early stage.

(*e*) PINK DISEASE (*CORTICIUM SALMONICOLOR*).

This disease causes considerable damage in Java but is of very little importance in Ceylon. Its occurrence on mature Rubber in this country is exceedingly rare, though it is more often found on young plants. *Corticium salmonicolor,* the causative fungus, has a wide host range and attacks a large number of tropical trees and shrubs.

Symptoms.—The disease usually originates in a fork, the first sign observed being a pink incrustation of interwoven fungal hyphae over the bark. This gradually extends and may completely encircle the tree. At the margin of a rapidly extending pink patch the fungus is sometimes seen as a very thin layer of long silken hyphae. Owing to the fact that the fungus spreads more rapidly over the surface of the bark than within it, the latter is usually healthy towards the margin of the pink patch. Under the central part of the patch, however, the bark has been killed and is brown and dry. Later the pink patch splits into lines running more or less at right angles to one another, and becomes faded in colour.

The growth of the fungus is dependent on wet weather, and is also favoured by shade. If allowed to develop unchecked the disease will spread rapidly under moist conditions, and may quickly encircle and "ring" a young stem. The disease is spread by spores which probably form upon jungle trees and are thence blown to neighbouring Rubber.

Control.—When very young trees are attacked they should be cut back well below the affected part, and all the diseased wood burned. Where the disease has attacked a large branch it is sometimes possible to cut away all the diseased bark and tar the wound. If the injury is extensive, however, it will be necessary to amputate the affected limb.

(*f*) MINOR STEM DISEASES.

Amongst the various minor stem diseases of *Hevea* are included a number of so-called "blights"—Thread Blight, White Stem Blight, and Horse-hair Blight. The parasitism of the fungi concerned has not been clearly established in these cases, and it is probable that the fungi are mainly epiphytic. Indeed the identity of the fungi themselves is in many cases not known.

White Thread Blight and Horse-hair Blight are striking in appearance owing to the conspicuous mycelial threads, white in the former and black "horse-hair-like" in the latter, which grow on and entertwine the small twigs and leaves. A number of dead twigs and leaves are usually found suggesting that the fungi are parasitic, but extensive damage has never been reported. Beyond removal of the dead stems no control measures are necessary.

Phyllosticta ramicola and *Glocosporium alborubrum* attack green shoots in a very similar manner. They are not themselves serious but may afford entry for *Botryodiplodia theobromae*, which can kill back the whole tree.

III. LEAF DISEASES.

There are two leaf diseases of importance in Ceylon: those caused by the fungi *Phytophthora palmivora* and *Oidium heveae* respectively. There are also various rim blights and leaf spots, but these are of very minor importance.

(a) *PHYTOPHTHORA* LEAF-FALL AND POD DISEASE.

The fungus causing this disease in Ceylon is *Phytophthora palmivora*, formerly known as *Phytophthora faberi*. In South India, where secondary leaf-fall is far more severe than in Ceylon, the disease is caused by an allied species, *P. Meadii*, which appears to be more virulent. The latter fungus has also been found on *Hevea* in Ceylon but is not of wide occurrence. The incidence of leaf-fall is intimately associated with the occurrence of the pod disease.

(1) POD DISEASE.

The pods are attacked while they are ripening during the S.W. Monsoon. They become a dirty watery green, either in patches or all over. The diseased areas become black and sodden and the whole fruit is soft and rotten. A white or greyish film of mycelium forms on the diseased patches and spreads over the whole fruit. Finally, the whole pod turns black, splits along the grooves, dries up, and remains hanging on the tree for a long time. The incidence of the disease is very markedly dependent on wet weather conditions, and a dry spell in the early weeks of the Monsoon will cause a distinct check in its spread.

The disease of the pods is economically more important as a precursor of leaf-fall than directly as a factor adversely affecting the seed crop.

(2) LEAF-FALL.

Symptoms.—Soon after the fruit rot has set in, the disease spreads to the leaves. The appearance of diseased leaves varies according to the nature of the fungus attack. If a spore from a diseased pod alights on a leaflet, watery blackish-green spots are formed. These spread to larger patches either down the centre along the mid-rid or spreading inwards from the margin. More frequently, however, the leaf-blade is not attacked, but the fungus develops on the leaf-stalk or at the base of the leaf-blade, and causes the leaflet to fall. In this case a discoloured area is seen on the leaf-stalk, or at its junction with the leaf-blade. The discoloured stalks often bear a small drop of coagulated latex about the middle of the diseased area. The leaves may fall when quite green, or they may first turn yellow or become mottled. They may fall as a whole, in which case the blades are very readily shaken apart from the leaf-stalks, or the leaflets and leaf-stalks may separate on the tree. In the latter case the fall of the stalks soon follows that of the leaflets in contrast to normal leaf-fall.

Phytophthora is also capable of attacking and killing back young green shoots, and this die-back may extend to the larger branches. Hence, after a severe outbreak of leaf-fall and pod disease, the presence of dead twigs and branches is a characteristic feature.

The development and spread of the disease is strikingly dependent on wet weather conditions. If June and July are months of continuous rain the disease will spread very rapidly and may cause serious defoliation. On the onset of dry weather the disease is immediately checked, and defoliated trees put out new leaves.

Economic Importance of Leaf-fall.—The economic importance of any disease must always ultimately be judged by the loss of crop entailed. In Ceylon there is little evidence of any decrease in yield due to *Phytophthora* leaf-fall, but in South India the disease is regarded as one of the most important factors responsible for that country's comparatively low yields.

The disease is often known as "secondary" leaf-fall, since it follows few months after the normal annual leaf-fall in the ordinary process of "wintering." When natural leaf-fall occurs the tree makes preparation by withdrawing valuable foodstuffs from the leaf for safe storage in the stem. When, however, a leaf is attacked by *Phytophthora* no such protective measures are possible, and the leaf carries with it to the ground a considerable quantity of manufactured carbohydrates and nitrogen-containing substances. This loss of food substances incidental to an abnormal leaf-fall is, however, only a small part of the strain to which the tree is subjected.

The whole manufacturing system of the plant is affected and while the tree is leafless it is, so to speak, living on its capital. The drain on the resources of a tree which is annually subjected to severe secondary defoliation in addition to the normal wintering is thus abundantly evident, and it is not surprising that the yield of areas of Rubber on which the majority of trees are thus severely defoliated is seriously impaired. In Ceylon severe defoliation of large areas of Rubber is rare, but in South India it is not uncommon in a bad year for 90% of the trees to lose nearly every leaf.

Control.—Many methods of controlling the disease have been tried. Since the fungus "overwinters" in dead branches and pods their removal should, theoretically, reduce the amount of the fungus on the estate. In practice, however, it is impossible to remove all such dead matter, and attempts to control the disease on these lines have, on the whole, given disappointing results. The problem resolves itself into manurial and fungicidal treatments.

Although the application of manures exercises no direct control over the fungus, it is probable that a healthy leaf resists infection to some extent. Any measures, therefore, such as the application of nitrogenous manures and the adoption of cultivation methods, which tend to build up a good strong foliage, will ameliorate the worst effects of the disease. In addition a well-nourished tree, even if severely defoliated, will more rapidly be able to put out new shoots and leaves and thus recover from the disease. In Ceylon it is probable that the adoption of a regular manuring programme and of cultivation methods assisting the conservation of moisture, will keep the disease in check.

In South India leaf-fall is too severe to be kept under control by cultivation methods, and the expensive and troublesome task of spraying has had to be adopted. Effective control of the disease is now being secured by spraying with Bordeaux Mixture. The average cost of this operation is about Rs. 15 - per acre, so that the method is not to be recommended unless absolutely necessary. At present the disease is not sufficiently severe in Ceylon to justify the expense of spraying, but it is not impossible that in the future this method may have to be considered. One of the chief difficulties in liquid spraying on a large scale in Ceylon would be the lack of a big extra labour supply for a few weeks only.

(*b*) *OIDIUM*. LEAF DISEASE.

This disease is caused by a fungus belonging to the class of "powdery mildews," *Oidium heveae*. The disease has been known in Java since 1918, but was first reported in Ceylon in 1925. In the main low-country districts

of Ceylon it is not of such serious consequence as in Java, but at certain mid-country elevations, notably in Matale and Uva, the disease is very severe and constitutes a serious menace to the health of the Rubber.

Symptoms.—*Oidium* can attack *Hevea* leaves of all ages and the effects of the attack differ according to the degree of maturity of the leaf. The disease is first evident as an attack on young leaflets when the trees are refoliating after wintering. If the leaves are attacked when still bronze-coloured and shiny they become dull and faded in patches, and may become slightly crinkled. The leaflets may fall in this condition or the tip may first die back, becoming bluish-black in colour. The symptoms are very similar when the attack is on slightly older leaves which have just turned green, except that in such cases the curling and crinkling is usually more pronounced. The white powdery superficial growth of the fungus consisting of mycelium and spores is sometimes clearly seen on the petiole and under surface of the mid-ribs of such young leaves, but more often it is only visible with a lens. The fallen leaflets soon shrivel on the ground, but in the case of a severely attacked tree they often form a conspicuous carpet of leaves. All three leaflets of any one leaf do not necessarily fall, so that a characteristic feature of diseased trees is the presence of petioles bearing one or two leaflets instead of three. Trees which are severely defoliated in this way usually put out a fresh crop of leaves and so recover. These secondary leaves may, however, be attacked in turn.

If the fungus attacks somewhat older but still immature leaves the effect is rather different. Such leaves are more resistant and the attack is confined to localised portions of the margin and mid-rib. These are prevented from growing normally, with the consequence that the leaflet becomes irregularly distorted into folds and crinkles. Severely attacked leaves are dull and yellowish. The leaflets do not usually fall so that this form of attack is not as serious as that on the very young leaves when complete defoliation of the tree may result. The attack on immature leaves is for convenience known as "primary" attack and occurs soon after wintering.

Oidium may also attack fully mature leaves, such an attack being termed "secondary." The first symptom of a secondary attack is the appearance of small yellowish translucent spots chiefly on the upper surface of the leaflet. The fine superficial hyphae of the fungus can be detected on these spots with a lens, and the subsequent production of spores gives the spots a white powdery appearance. As the spots grow larger they turn purple-brown in colour and eventually dry up, while the dead tissues in the centre may fall out, leaving irregular holes. No hard-and-fast distinction can be drawn between this secondary form of attack and that previously described on the immature leaves; in fact a characteristic feature of the disease is the existence of distorted leaflets with the mottled appearance of the secondary attack.

Oidium also attacks and destroys the flowers, and the young inflorescences are often thickly covered with a growth of mycelium and spores. In a badly-affected area the complete absence of seed is a striking feature.

The fungus is spread by means of conidia (spores) which are produced in great abundance on the superficial mycelium. These spores are responsible for the "bloom" often seen on infected leaves. In the Matale and Uva districts the relatively dry and cool atmospheric conditions are more favourable to the production of spores than are the warm and damp conditions of the low-country, and in these mid-country districts far more white superficial growth is seen than in the low-country.

In the low-country, where *Oidium* is not so severe as in certain districts at higher elevations, the disease usually appears in February or March, is active for a few weeks, and then disappears as suddenly as it came. Hence a defoliated tree which puts out a second crop of leaves is rarely attacked a second time, and so recovers at the cost of food reserves. So far as is known at present there are no strains of *Hevea* inherently resistant to the disease. Any tree, therefore, which produces new leaves during the period of *Oidium* activity will be attacked and partially defoliated, but early winterers, whose leaves are mature when the fungus becomes active, escape except possibly for secondary attack. In severely affected areas, on the other hand, although the disease exhibits a period of maximum intensity shortly after the normal wintering, the fungus may remain active throughout the year. In this way many trees are subject to a continuous process of leaf-fall and refoliation, the leaves becoming smaller and poorer in quality at each successive recovery.

Such a continual defoliation no doubt results in a depletion of food reserves and general lowering of the vitality of the tree. In consequence a physiological die-back of twigs is a characteristic feature of badly-attacked areas. Such dead or dying twigs are liable to afford entry for *Diplodia* which may kill the branch or even the whole tree.

Economic Significance.—Although at the present time there is no reliable evidence of a decrease in yield due to *Oidium* in Ceylon,* it is impossible not to view with concern a disease which, in certain districts, causes severe and constant defoliation of a very large percentage of trees. The damage done to the vitality of the tree by an abnormal leaf-fall must be reflected in the bark renewal, and eventually in the yield per acre.

Control.—As in the case of *Phytophthora* leaf-fall there are two main lines along which control may be secured: (1) manurial and (2) fungicidal.

* Since writing this manuscript yield records kept on a severely affected estate have indicated considerable decreases in yield.—R.K.S.M.

(1) The application of nitrogenous manures, by benefiting the quality and quantity of the foliage, will probably minimize the worse effects of the disease, and will help defoliated trees to recover. As is the case with *Phytophthora* leaf-fall in South India, however, manurial and cultivation methods are quite inadequate in areas badly attacked by *Ordium*. In order to control the disease a method must be adopted whereby the fungus is destroyed.

(2) Liquid spraying with Sulfinette, a lime-sulphur preparation, has been tried in Java and Ceylon. A certain degree of control was secured in the former country, but the method is very expensive and slow.

Dusting with finely divided sulphur powder from power-driven dusters seems likely to solve the problem of *Oidium* control. Very successful results have been obtained in Java, and experiments which are at the present time being conducted in Ceylon also promise excellent results. The method has the advantages of being extremely quick and comparatively cheap. In Java 200 acres per day is an average area covered by one machine. Although no definite statements can yet be made it will probably be possible to secure complete or almost complete control of the disease in the worst affected areas at a cost of about Rs. 5/- per acre for the first year, while a small expenditure in subsequent years may be necessary.

It is probable that sulphur dusting will have to be adopted in badly-affected districts if the health of the trees and the yield per acre is to be maintained. Whether it will be found desirable to adopt the method in the main low-country districts where the damage due to *Oidium* is not so severe, remains to be seen.

(c) MINOR LEAF DISEASES.

There are many rim-blights and indeterminate leaf spots which affect *Hevea* leaves. Except in rare cases these blemishes are of no importance, and the parasitism of the fungi associated with them has not in most cases been established.

A leaf-scorch due to the application of calcium cyanamide in dry weather has recently been much in evidence. The margin of the leaf-blade dies back and becomes whitish in colour, and the appearance is similar to that of a rim-blight of fungus origin. In severe cases the leaflets may fall. The burning is due to the formation of a toxic compound, dicyanodiamide, which is liable to be formed when calcium cyanamide is applied to soils with insufficient moisture. This manure is of great benefit when applied under suitable conditions, but it should not be applied in dry weather, particularly to soils deficient in humus.

IV. DISEASES AND PESTS OF NURSERY PLANTS.

Young growing plants are liable to various attacks to which they are immune when mature, or which are then of no importance. The recent increase in the use of valuable bud-grafted material has focussed attention on such ailments.

(*a*) *PHYTOPHTHORA PALMIVORA.*

A new disease of Bud-shoots caused by *Phytophthora palmivora* (*P. Faberi*) has recently been investigated. This disease has only, at the present date, been reported as occurring in nature on young shoots of bud-grafted Rubber, but experiments have shown that seedlings are also readily attacked. It appears that more than one strain of the fungus is associated with the disease.

Symptoms.—The green shoot is attacked a few inches below the extremity. The disease first appears as a blackish, watery-looking, sunken area on one side of the stem, which spreads chiefly downwards and kills back the shoot to the extent of the latest growth increment. The fungus does not appear to spread readily to the more mature portions of the shoot, and unless *Diplodia* gains entrance to kill the plant right back, the disease is checked. The disease is largely dependent on wet weather conditions. The chief danger lies in an outbreak in a bud-wood nursery in wet weather. If the bud-shoots were very young they might quickly be killed back to the stock, and a supply of valuable material thereby lost.

Control.—During wet weather a careful watch should be kept on young bud-shoots of valuable material, and any diseased shoot should be cut off well below the affected part and burned. Neighbouring healthy shoots should be protected by periodical applications of Bordeaux Mixture in wet weather. (Directions for making Bordeaux Mixture are given in the Appendix.)

(*b*) *OIDIUM.*

Oidium may make its appearance in the nursery. The symptoms are similar to those of an attack on mature Rubber described in Section III. The disease can be controlled by dusting periodically with finely divided sulphur powder, or spraying with a solution in water ($\frac{1}{4}\%$-$\frac{1}{2}\%$) of Sulfinette. If the latter fungicide is used the application should be made in the evening or on dull days, since a hot sun on freshly sprayed leaves may cause a leaf scorch.

(*c*) MITES.

Among the various pests which check the growth of young plants, mites are the most important, and in dry weather they may become a serious pest in nurseries. Attacked leaves become irregularly twisted and distorted, and defoliation of young leaflets may result. The mites are usually found on the under side of the leaflets, though often only their white cast-off skins are seen. With a lens the puncture in the epidermis, through which they suck the cell sap, may be seen. Mites usually attack the poorest plants, so that manuring and cultivation methods which ensure quick growth are to be recommended. Efficient control can be secured by periodical dusting with sulphur powder. Several makes of hand dusters are on the market. On a small scale sulphur can be applied by heating on a linen bag in which the dust is loosely contained. It is worth noting that to the uninitiated an attack by mites is often similar in appearance to *oidium* disease, and that both are controlled by sulphur.

(*d*) MISCELLANEOUS.

Slugs are often found to eat off the young terminal shoot. In the daytime it is usually possible to find the slugs underneath stones etc. They may to some extent be discouraged by periodically dusting with smokehouse ashes, and by putting a barrier ring of ashes on the ground round each plant.

Lizards also cause trouble by eating off the terminal bud. It is probable that all such pests will be to some extent controlled by the application of the sulphur or copper fungicides which may be made in the control of the more serious affections. It is a sound rule that all young shoots in a nursery of valuable bud-grafted material should be dusted with sulphur powder every 10 days in dry weather, and sprayed with Bordeaux Mixture every week or 10 days during wet weather.

V. DISEASES AND PESTS OF COVER CROPS.

Erect cover crops which grow woody are liable to be attacked by various root fungi. An outbreak of root disease is only likely to be important, however, if the fungus is also parasitic on *Hevea*. In the same category may be placed attacks of Pink Disease (*Corticium salmonicolor*), to which *Desmodium spp.* are liable. Diseased plants must be removed and burned.

Dolichos Hosei (*Vigna*) is known to be attacked by two fungi, though in neither case is the disease often serious :—

(*a*) *RHIZOCTONIA SOLANI.*

This fungus attacks *Vigna* in wet weather and kills it back in small circular patches. Diseased leaves are at first dark bluish-green in appearance. They are wet and stick together in a "mushy" tangle, being joined by the fine silken hyphae of the fungus. Later the leaflets dry up, turn yellow, and fall to the ground. The diseased areas soon recover on the advent of dry weather. The fungus forms hard, brown, seed-like sclerotia which fall to the ground and lie inactive until the next spell of wet weather. They then germinate and the hyphae re-infect the *Vigna*. The disease is seldom sufficiently severe to necessitate the adoption of any control measures.

(*b*) *UROMYCES SP.*

Vigna leaves are very commonly attacked by a "rust" fungus, *Uromyces sp.* The fungus forms small brown spots, irregular in shape and angular in outline. Diseased leaflets may turn yellow and fall. It is improbable that a cover is ever completely killed by this disease, but in dry weather it is often considerably thinned.

(*c*) KALUTARA SNAIL (*ACHATINA FULICA.*)

If there is no fungus disease of any serious consequence on *Vigna* there is a pest which has been responsible for the destruction of thousands of acres of this cover in Ceylon. The Kalutara snail, *Achatina fulica*, is well known in most districts and makes serious depredations on many plants besides *Vigna*.

It is unfortunate that no thoroughly reliable and economical means of exterminating this pest has yet been devised. A number of animals destroy the Kalutara snail, of which ducks, jungle crows, the ruddy mongoose, and glow-worms may be mentioned, but control by these means has not been found practicable on a large scale. The only poison method which has been used to any extent is that advocated by Mr. H. W. Roy Bertrand. A thick lime wash containing ½ to 1 pint of "Atlas" arsenical preservative to 20 lb. of lime is daubed on rocks, stone terraces, etc., preferably on the under surface to obtain protection against rain. Alternatively the poison is made up thicker and put out in stiff lumps. The snails are attracted to the lime and are killed by the "Atlas." The value of this method on an estate scale is doubtful. Some superintendents have found the method successful, while others have had no appreciable results. It is probable that collecting the snails by hand and destroying them in mass accounts for a greater number of snails per rupee expenditure, but it cannot be claimed that this method provides really effective control at an economic figure.

APPENDIX.

(a) BORDEAUX MIXTURE.

Since the fungicidal and adhesive properties of Bordeaux Mixture are entirely dependent on its correct compounding, the following directions should be closely followed. The proportions given below are for a 3-3-50 mixture which is considered to be a suitable strength for application to young shoots and leaves. Weaker or stronger Bordeaux Mixtures are made similarly, and with the same copper sulphate to quicklime ratio.

Copper Sulphate	...	...	3 lb.
Freshly burned lime	...	...	3 ,,
Water	...	...	50 gallons.

Dissolve the copper sulphate in 5 gallons of water in a wooden or earthenware vessel. It is convenient to suspend the copper sulphate in the water overnight in a piece of old sacking. The lime is slaked gradually for an hour or more, made into a uniform paste with water, and then made up to 45 gallons in a barrel. The copper sulphate is then poured into the milk of lime stirring all the while. It is important that the copper sulphate be added to the lime and not *vice versa*. On no account must iron vessels be used.

It is essential that all the copper sulphate should be neutralised by the lime. To test this hold a bright knife blade in the mixture for a minute. If it is tarnished a copper red more lime must be added. A more delicate test consists of adding a little weak potassium ferrocyanide solution to a few drops of Bordeaux Mixture in a saucer. A brown colour indicates excess of copper, in which case more lime must be added.

Unless a preservative is added Bordeaux Mixture does not keep and must be freshly mixed immediately before use. Since in the budwood nursery it will be necessary to use small quantities of the fungicide at relatively frequent intervals, it is useful to add a preservative to the mixture so that the latter need not be made up afresh on each occasion. For this purpose dissolve pure cane sugar in the copper sulphate at the rate of 1 oz. to 10 gallons of the completed mixture. The mixture may then be kept in a covered receptacle and, after shaking, used when required. Sugar purchased locally has preservative properties but is not so satisfactory as pure cane sugar.

(b) BURGUNDY MIXTURE.

Burgundy Mixture has very similar properties to Bordeaux Mixture and may be used when freshly burned lime is not easily obtainable. The following is a good prescription :—

Copper Sulphate	... ...	4 lb.
Washing soda	... ...	5 ,,
Water	... ...	50 gallons.

The mixture is made in the same way as described above for Bordeaux Mixture, washing soda being substituted for lime. A big excess of soda is liable to scorch young leaves and it is therefore important that the quantities indicated should be carefully adhered to, and that only fresh soda should be used. Tests for excess copper are described in connection with Bordeaux Mixture.

Burgundy Mixture, like Bordeaux, does not keep and must be used within a few hours of its preparation. For use in budwood nurseries Bordeaux Mixture preserved with sugar is considered preferable.

(c) SULFINETTE.

Sulfinette is a proprietary lime-sulphur mixture and is sold in a convenient form for the use of the planter in nurseries. The liquid is simply diluted with water to the required concentration. Care must be used in its application, since if made in bright sunlight even very dilute solutions, viz., $\frac{1}{4}\%$, may cause burning of young leaves.

(d) SULPHUR.

For use in nurseries ordinary flowers of sulphur is not sufficiently finely ground. Better resuts will be obtained in the control of *Oidium* and mites if one of the specially prepared grades of fine sulphur be used. The sulphur should be applied with a hand duster of which there are several makes available.

(e) TAR-ACID DISINFECTANTS.

A large number of water-miscible tar-acid disinfectants suitable for the control of Bark Rot and other diseases are on the market. Of these Brunolinum Plantarium is mentioned above, but other proprietary articles may equally well be used provided that the strength is previously ascertained. To make up a 10% solution in water add 1 part of the disinfectant to 9 parts of water.

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